

Basic Electrical Engineering (BEE)

2026 End-Semester Exam Blueprint & High-Probability Predictions

1. Categorized Repeated Questions (2024-2025 Analysis)

AC Fundamentals & Single Phase Circuits

- Draw Impedance and Power triangles. Define and state units of Active, Reactive, and Apparent power.
- Derive the RMS value of a sinusoidal current/voltage in terms of its peak value.
- State the condition for resonance and define the Q-factor of a series RLC circuit.
- Draw waveforms and phasor diagrams for purely R, L, and C circuits.
- Derive the expression for current drawn by a purely inductive/capacitive circuit when $V_m \sin(\omega t)$ is applied.

Three-Phase Systems

- Define: Balanced Load, Phase Sequence, and Symmetrical Supply System.
- Prove that the phasor sum of three symmetrical phase voltages/EMFs (RYB) is equal to zero.
- Derive the relationship between Line and Phase Voltage/Current for Star and Delta connected loads.
- Draw phasor diagrams for Star and Delta connected inductive/capacitive loads.

Transformers & DC Machines

- List the various losses in a transformer and state where they occur.

- Explain the working of a single-phase transformer on No-Load with circuit and phasor diagrams.
- Derive the condition for maximum efficiency of a single-phase transformer.
- Explain the necessity of a starter in a DC motor.
- Draw schematic diagrams and write voltage equations for DC Series, Shunt, and Compound motors.

Safety, Wiring & Appliances

- Explain the functions of MCB, MCCB, and ELCB. Compare a Fuse with an MCB.
- Write a short note on the BEE Star Rating system for electrical equipment.
- What is earthing? Why is it necessary and what are the methods?
- Explain the construction and working of an Electric Geyser / Electric Iron.

2. 2026 High-Probability Exam Predictions

Prediction 1: Single-Phase Series RLC Numerical 6 Marks

Expected Question: A series RLC circuit (e.g., $R=10\Omega$, $L=0.1\text{H}$, $C=150\mu\text{F}$) is connected across a single-phase 230V, 50Hz supply. Calculate: i) Impedance, ii) Current drawn, iii) Power Factor, iv) Active Power, v) Reactive Power. Draw the phasor/power triangle.

NUMERICAL SOLVING GUIDE & FORMULAS

1. Reactances:

$$X_L = 2\pi fL$$

$$X_C = 1 / (2\pi fC)$$

2. Impedance (Z):

$$Z = \sqrt{R^2 + (X_L - X_C)^2}$$

3. Current (I):

$$I = V / Z$$

4. Power Factor (cosφ):

$$\cos\phi = R / Z$$

(Lagging if $X_L > X_C$, Leading if $X_C > X_L$)

5. Powers:

$$\text{Active Power (P)} = V \times I \times \cos\phi \quad (\text{or } I^2R) \quad [\text{Watts}]$$

$$\text{Reactive Power (Q)} = V \times I \times \sin\phi \quad (\text{or } I^2X) \quad [\text{VAR}]$$

$$\text{Apparent Power (S)} = V \times I \quad [\text{VA}]$$

Prediction 2: Three-Phase Star/Delta Numerical 6 Marks

Expected Question: Three identical impedances (e.g., $Z = 8+j6 \, \Omega$ or $Z = 30\angle 30^\circ \, \Omega$) are connected in Star (or Delta) across a 3-phase, 400V, 50Hz supply. Calculate: i) Phase Voltage, ii) Phase Current, iii) Line Current, iv) Total Active Power consumed.

NUMERICAL SOLVING GUIDE & FORMULAS

STAR Connection Rules:

$$V_{ph} = V_L / \sqrt{3}$$

$$I_{ph} = I_L$$

DELTA Connection Rules:

$$V_{ph} = V_L$$

$$I_{ph} = I_L / \sqrt{3}$$

Calculations:

$$1. \text{ Find } |Z| = \sqrt{R^2 + X^2} \text{ and } \cos\phi = R / |Z|$$

2. $I_{ph} = V_{ph} / |Z|$
3. Find I_L using Star/Delta rules above
4. Total Power $P = \sqrt{3} \times V_L \times I_L \times \cos\phi$
(Alternatively: $P = 3 \times V_{ph} \times I_{ph} \times \cos\phi$)

Prediction 3: Transformer Efficiency Numerical 6 Marks

Expected Question: A 40 kVA, single-phase transformer has a full-load copper loss of 800W and an iron loss of 400W. Calculate: i) Efficiency at full load and 0.8 p.f. lagging, ii) Efficiency at half load and unity p.f., iii) The load kVA at which maximum efficiency occurs.

NUMERICAL SOLVING GUIDE & FORMULAS

Variables:

x = Fraction of full load (1.0 for FL, 0.5 for HL, 0.25 for 1/4 load)

P_i = Iron Loss (Constant at all loads)

P_{Cu} = Full Load Copper Loss

Copper Loss at load 'x':

$$P_{Cu(x)} = x^2 \times P_{Cu}$$

Efficiency (η) Formula:

$$\eta = \left[\frac{(x \times \text{kVA} \times \cos\phi)}{(x \times \text{kVA} \times \cos\phi + P_i + x^2 \times P_{Cu})} \right] \times 100$$

Condition for Maximum Efficiency:

$$\text{Variable Loss} = \text{Constant Loss} \Rightarrow x^2 \times P_{Cu} = P_i$$

$$x = \sqrt{(P_i / P_{Cu})}$$

$$\text{kVA at max } \eta = x \times \text{Full Load kVA}$$

Prediction 4: Safety Devices & BEE Star Ratings 15 Marks

Expected Q4A (8 Marks): What is the function of MCB, MCCB, and ELCB in electrical circuits? Compare a Fuse with an MCB.

Expected Q4B (7 Marks): Write a short note on the BEE Star Ratings of electrical equipment. How does it benefit the consumer?

THEORY ANSWERING TIPS

MCB (Miniature Circuit Breaker): Protects against Overload and Short Circuit. Electromechanical relay. Resettable.

MCCB (Molded Case Circuit Breaker): Similar to MCB but for higher current ratings (up to 2500A) and adjustable trip settings.

ELCB/RCCB (Earth Leakage): Protects humans from electric shock by detecting ground fault/leakage currents (imbalance between phase and neutral).

Fuse vs MCB: Fuse melts and must be replaced (slow, unreliable); MCB trips and can be reset (fast, sensitive, reusable).

Star Ratings (BEE): Initiative by Bureau of Energy Efficiency. Rates appliances from 1 to 5 stars based on energy efficiency.

More stars = lower electricity consumption = lower utility bills and reduced carbon footprint. Applies to ACs, Refrigerators, Motors, etc.

Prediction 5: Transformer Theory or DC Machine Schematics 6 Marks

Expected Question (Option A): Explain the working of a single-phase transformer on No-Load. Draw the necessary circuit and Phasor diagram.

Expected Question (Option B): Derive the condition for maximum efficiency for a single-phase transformer.

Expected Question (Option C): Draw schematic diagrams and write voltage equations for DC Series and Shunt motors. Why is a starter needed?

THEORY ANSWERING TIPS

No-Load Transformer: Draw primary winding connected to V_1 . Current I_0 splits into I_w (core loss component, in phase with V_1) and I_m (magnetizing component, lags by 90°). Draw flux Φ in phase with I_m . E_1 lags Φ by 90° .

DC Motor Starter: Back EMF (E_b) is zero at starting ($N=0$). Armature current $I_a = (V - E_b) / R_a$. Since R_a is very small, starting current is dangerously high. Starter adds external resistance to limit starting current.

Voltage Eq: $V = E_b + I_a R_a$ (Shunt), $V = E_b + I_a (R_a + R_{se})$ (Series).

3. Must-Learn Topics (Highest Priority)

- **AC Power Triangles:** Be able to draw the Impedance (R, X, Z) and Power (P, Q, S) triangles flawlessly. This is almost guaranteed as a 3-mark or 6-mark question.
- **3-Phase Derivations:** Memorize the geometric derivation of $V_L = \sqrt{3} V_{ph}$ for Star connections using phasor diagrams.
- **Proof of Zero Sum:** Know how to mathematically or graphically prove that $e_R + e_Y + e_B = 0$ (using $\sin(\theta) + \sin(\theta-120^\circ) + \sin(\theta-240^\circ) = 0$).
- **Transformer Losses:** Distinguish clearly between Core/Iron losses (constant, occur in magnetic core due to hysteresis & eddy currents) and Copper losses (variable, occur in windings due to resistance).

- **Appliance Wiring:** Understand the internal components of an Electric Geyser (heating element, thermostat, anode rod) and Electric Iron.